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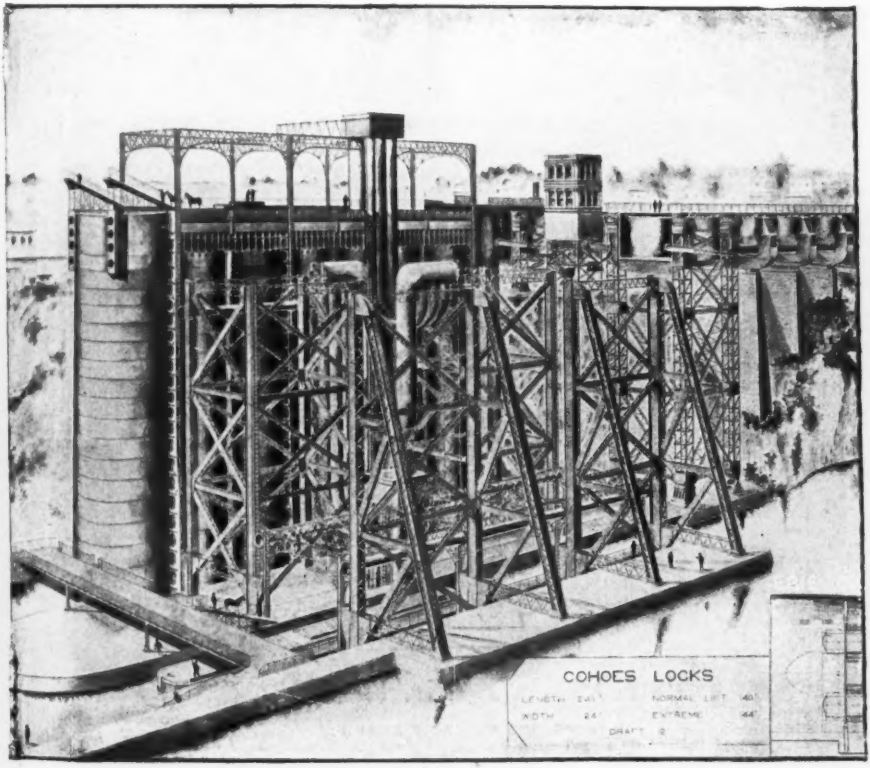
VOL. V. NEW YORK, AUGUST, 1900. No. 6



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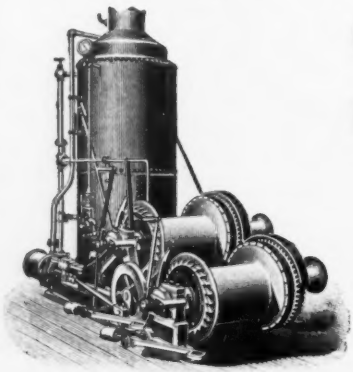

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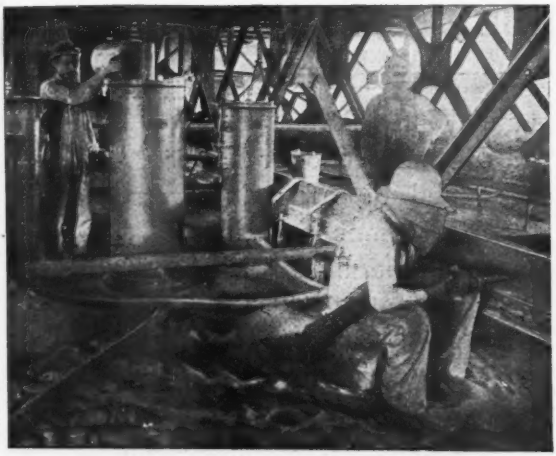

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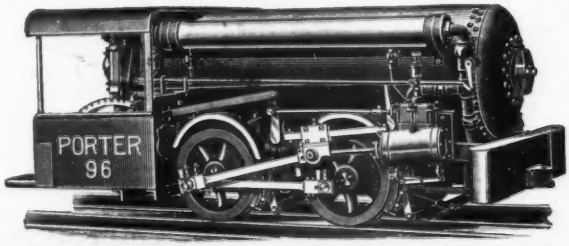

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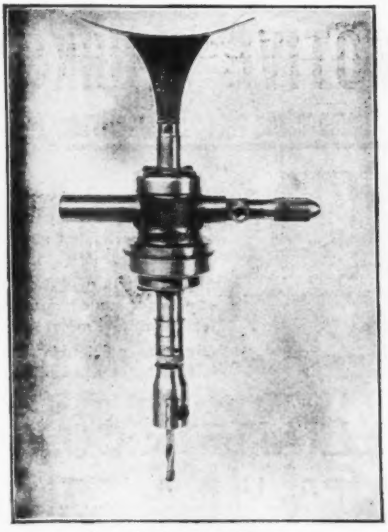

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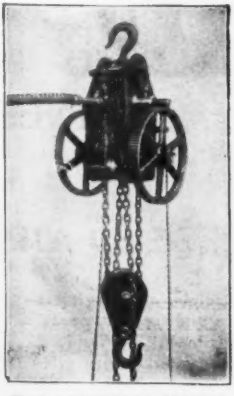

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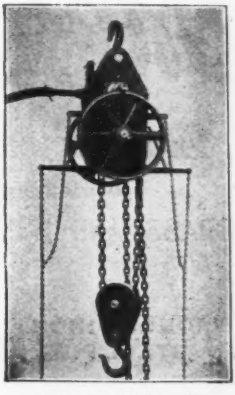

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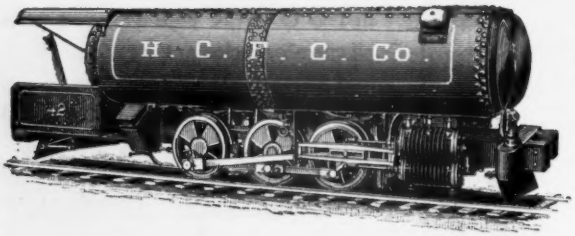

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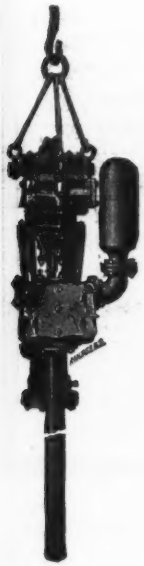

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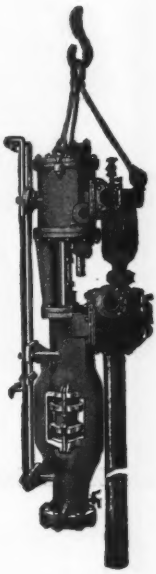

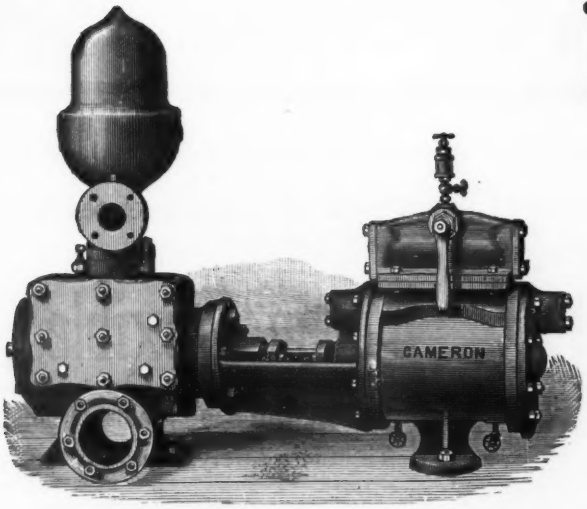

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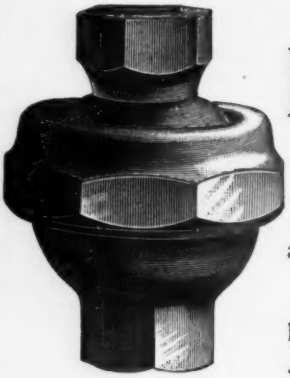

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Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

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Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York N. Y. Post Office.

VOL. V. AUGUST, 1900. NO. 6.

Among our enterprising American manufacturers, the Chicago Pneumatic Tool Co., have reached out to foreign fields in the development of their business to an extent which is very much to the credit of the company. Even in distant Russia this American invention has attracted attention and has recently been the subject of a paper read by Mr. Beljankin, naval engineer of Russia. Mr. Beljankin read his paper before the St. Petersburg Society of Marine Engineers on the "Displacement of Hand Work by Mechanical Appliances in American Shipyards." He says:

"Pneumatic tools have not been introduced all at once, but were found to be necessary on account of strikes. For, not to be dependent on workmen, it was necessary to apply all knowledge for the invention of such apparatus which anybody could work easily without having any experience, and which, at the time, would give the highest obtainable results. All these requirements are fulfilled by pneumatic tools."

Mr. Beljankin has been in American shipyards during the period of one and a half years, and has been busy with the application of improved tools. In the beginning of his discourse the driving of one hundred rivets was calculated, and he prepared quite an interesting table on the comparative cost.

In Russia a riveter gets 42½ cents in comparison with from $2 up which American riveters are paid. Mr. Beljankin states: "As far as caulking, drilling and chipping is concerned, hand use is altogether out of use in America. In the latter cases hand work is not able to compete. Thus, it may be stated, that caulking may be performed by one laborer in America to the extent of 280 feet, while our workmen can do only up to 20 feet. For the whole work, 280 feet, the American workman gets $4.40. We should have to pay for the same amount of work $14, and instead of one workman, we would have to employ fourteen to do the work at the same rate. The same could be said about drilling and chipping.

The passenger car repair shops of the Lake Shore & Michigan Southern Railway at Buffalo, N. Y., have compressed air at hand for various purposes. An overhead trolley and air hoist supported partly on posts and partly hung from the roof of the shop is used for lifting trucks up off the wheels. An air blast is used in connection with gas to burn off the paint of cars to be repainted.

In the paint stock room the liquids which are kept in large tanks below are unloaded from barrels by means of compressed air.

The upholstering department is provided with an air nozzle for dusting and cleaning cushions and backs of seats. Air is supplied by three compound air pumps, and the pressure used for hoists and other appliances is 105 pounds.

In compressed air practice, as in engine or boiler practice, it is well to install a larger machine than is needed at the time, because it invariably happens that the demand increases, and compressors, in common with other apparatus, work best when not driven hard.

Compressed Air Machinery

The Dutton Pneumatic Balance Locks for Canals.*

By Chauncey N. Dutton, New York, Member of the Institute.

These locks float on compressed air confined in their lower open-bottomed air chambers, whence it displaces water. Each lock carries a gated tank containing sufficient water to float the boats. When one lock descends the other ascends, the descending lock impelling the air from its air chamber into the air chamber of the ascending lock through a 13-foot, valve-tontrolled connecting type. No compressed air is discharged into the atmosphere or wasted. The moving force is an excess of weight in the descending lock, in which the draft of water is one foot greater, such "surchage" being 330 tons. The greatest energy-rate is 1,150 horse-power; the average, 115 to 150 horse-power.

At Cohoes, the lift is 144 feet. At Lockport the normal lift is 57 feet 5 inches, and the extreme lift, when floods raise the upper level, 62 feet 5 inches. The least draft is 12 feet; the width, 28 feet at the bottom and 30 feet at the top; the clear or effective length 310 feet.

They will pass up-stream two boats drawing 12½ feet and carrying each 1,350 tons, or 2,700 tons of cargo per lockage; and down-stream two boats drawing 13½ feet and each carrying 1,450 tons, or 2,900 tons of cargo per lockage.

They will make their stroke in one minute, and, allowing for entry and exit, are expected to detain boats eight or ten minutes.

The locks are built of steel.

Each has an upper, gated lock chamber, and a lower, open-bottomed air ber containing compressed air, on which it floats, and as the volume of its air-charge is varied, moves up and down in a pit or deepened portion of the lower level of the two which they connect.

The locks are kept from tilting sidewise by guides, and from pitching endwise by an automatic leveling apparatus, consisting in fixed racks, anchored to terra firma; parallel racks built on the locks, and hollow builtup shafts armed with pinions, which mesh with the opposite parallel racks, on which they hang, without other bearings, and between which they roll when the lock moves.

The air chambers are so proportioned that they automatically differentiate the air pressure, so that the lock which descends forces the elevated lock up against its anchors with an effort exceeding by one-third the weight of said lock and its load, so that it may be connected with the upper level, and used in the roughest manner with entire safety.

The devices to retain the elevated lock against the unbalanced hydrostatic pressure, and the gates and other parts which are liable to ramming, will sustain ramming by boats going 3 miles per hour.

If injured boats sink in a lock, it can be used as a dry dock.

The locks can be raised clear of the water for painting and repairs.

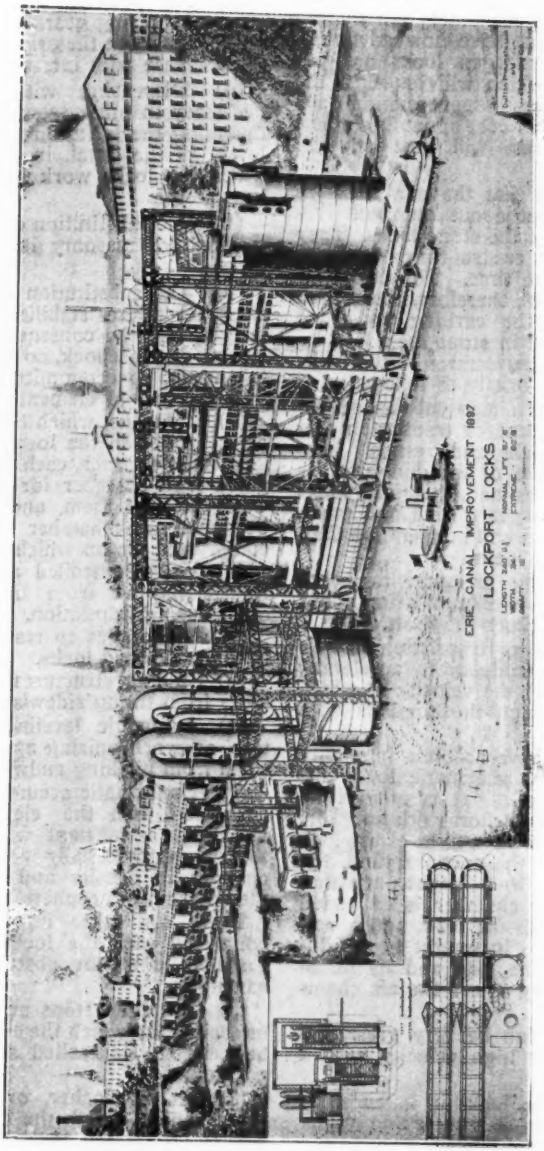
At Lockport each lock weighs 1,500 tons, and will contain over 4,500 tons of water. The weight in motion exceeds 12,000 tons.

The first locks at Lockport, opened in 1825, passed boats 3 feet 5 inches draft, 14 feet 5 inches wide, 78 feet 8 inches long, carrying 80 tons. They were replaced about 1838 by the present stone locks, which pass boats 6 feet draft, 17½ feet wide, 98 feet long, carrying 250 tons. These locks are in a remarkable state of preservation for old limestone masonry exposed to our northern winters. The stone shows little decrepitation, and most of the joints are still tight, showing that the cement was good.

The detention at the present locks is frequently several hours, and never less than one hour, because the fleets have to be broken up. The new locks will pass double-headers in eight to ten minutes.

The present stone locks cost $698,000. The first estimate for the steel locks, made in December, 1896, was $576,000, but

*An address delivered before the Franklin Institute, Philadelphia, November 16, 1897, on the "Pneumatic Balance Locks," approved by the State Engineer and adopted by the Canal Board of the State of New York, to replace five pairs of lift locks at Lockport, and two pairs of guard locks between Lockport and Buffalo; and sixteen pairs of lift locks, known as "The Sixteens," at Cohoes, on the Erie Canal, in New York State. Revised by the author for publication.


ERIE CANAL IMPROVEMENT 1897
LOCKPORT LOCKS

when completed plans were adopted by the Canal Board, June 24, 1897, the estimate was put at $499,000. The market prices of steel and machinery fell sharply in the interim, but have now advanced, and when the enlarged locks are put under contract, which will be when the Legislature makes appropriation for them, the work will cost about $1,000,000. The Cohoes locks will cost one-half more.

It will be seen that the new locks at Lockport will cost about one and five-eighths the cost of the stone locks. They will handle units twelve times as large in one-sixth of the time. The dollar invested in them has, therefore, more than forty-four times the earning power of the dollar invested in stone locks.

The characteristic features of the locks may be described briefly as follows:

(1) Compressed air is substituted for water as the element of translation and support of the locks and vessels. Increasing the height of lift does not increase the pressures, and, therefore, locks of any height are practicable and much cheaper in first cost and in operation than a flight of low lift locks.

(2) The working pressures are very much reduced, the maximum being about one and one-half times the draft.

(3) The motion of translation is uniform, having no tendency to accelerate, being regulated by the velocity at which air can pass through the conduits with the given head.

(4) The locks have absolute immunity from falling. The pneumatic lock falls up, if it falls at all. It is pressed up firmly against the anchors with an effort much greater than the weight of the lock and its load. If the anchors yield, the lock is forced up to a height such that the air in the air chamber is expanded to equilibrium with the load, and a volume of water equal in weight to the difference between the load and its initial excess of buoyancy enters the air chamber.

(5) The speed can be very great, because air flows at high velocity with a slight head.

(6) Working the locks in balance, by slight differences in weight, saving 95 per cent. of the water heretofore used, and avoiding heavy currents in the canal sections.

(7) The water-trap valve for controlling the air conduit.

(8) The powerful automatic leveling, or synchronizing gearing, of construction cheap, such that the price per pound does not increase with increased power.

(9) Dispensing with the dry-dock necessary in other types of lift lock and operating the locks directly in the lower level of the canal, in a pit; the pit in which the locks work being part of the lower level.

(10) The substitution of steel, mainly in tension, for masonry in the lock structures.

(11) The substitution of elastic resistance for mere stability due to dead weight, and the consequent reduction of strains due to shock, so that they can be taken care of economically.

The principal elements of design are:

(1) The locks, which float and work in a pit formed in the lower level, and are identical structures, each having an upper gated lock chamber for the vessels and water to float them, and a lower open-bottomed air chamber containing the compressed air on which they float.

(2) Valve-controlled air conduits for transferring air from one lock to the other during translation.

(3) Anchorages to restrain the super-buoyant elevated locks.

(4) Guiding structures to prevent the locks from tilting sidewise.

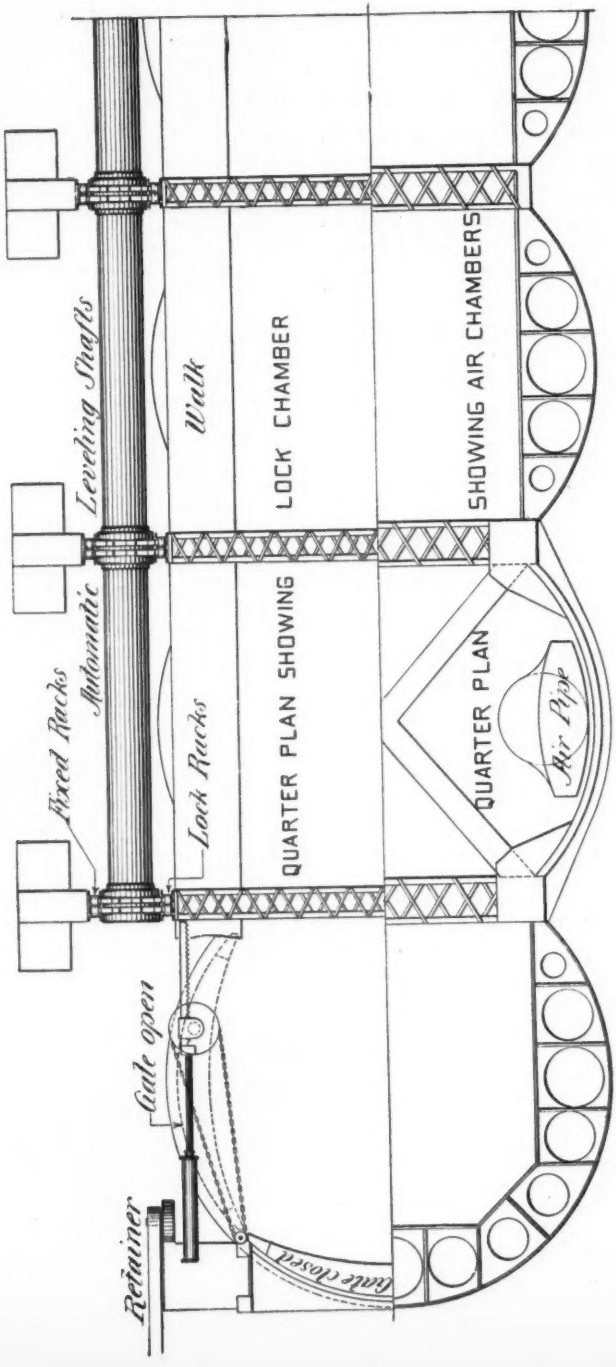
(5) Automatic leveling, parallel motion, or synchronizing apparatus, to keep them from pitching endwise.

(6) A pneumatic accumulator, which is connected with the elevated lock and maintains a constant working pressure therein, automatically compensating for changes in density and temperature of the adjacent atmosphere.

There are other important elements connected with the locks, which, while desirable, are not absolutely essential, namely:

(7) Hydraulic stops and accumulator-intensifier, by which the elevated lock can be perfectly controlled and adjusted in position.

(8) An interlocker, or sequence machine, which orders the operations incident to the motion of the locks, by means of valve-controlled compressed air transmissions.


Fixed Racks
Automatic
Leveling Shafts
Walk
LOCK CHAMBER
SHOWING AIR CHAMBERS
Lock Racks
QUARTER PLAN SHOWING
QUARTER PLAN
Air Pipe
Gate open
Retainer
Gate closed

(9) Automatic stop machines, one geared to each lock, adjustable to varying water levels, which prevent the locks from running away and automatically control the variations in depth of water when elevated.

A recital of the difficulties will aid in forming a clear conception of the motive and functions. A lock is the heaviest of engineering structures, carries per square foot a load greater than the load per running foot of the heaviest railroad bridge, and is subject to tremendous and cumulative distorting forces, which necessitates that the structure be of simple type and extreme power, and automatically leveled and controlled by apparatus strong enough to beyond peradventure arrest distorting forces in their incipiency and annul their cumulative tendency.

The locks are liable to be bumped and rammed and to have boats carry away the outboard gate and sink with the boat's nose overhanging the end of the lock. A boat in this position, half the length of the lock, or a boat of said length sunk in one end of the lock, would overload that end with a weight equal to the weight of the boat and cargo. The leveling, or synchronizing apparatus, must be powerful enough to sustain this distorting effort and distribute it, and, furthermore, it must be automatic, for were the least interval of time to intervene between the application of the distorting forces and the action of the leveling apparatus, the loaded end would pitch, the water would run off the opposite end and pile up in the loaded end, giving a cumulative effect, combined with shock, which must inevitably destroy any non-automatic apparatus, how strong soever it might be, and ruin the lock.

Description of the Lock Structures.

The lock structures are identical. The lower part is an open-bottomed air chamber, the roof of which forms the floor of the gated lock chamber.

The air chamber is formed in eight bays, to avoid beam strains and framing in the side walls, which are segments of cylinders tied transversely at the points of intersection. The cylindrical segments do not quite meet, being united by longitudinal plates, and the ties are in double lines, so that by lacing them together stiff transverse strut members can be formed where desired. Strut members are so formed at the bottom and at two intermediate horizontal planes, where chord plates are united with the walls, so that the entire chamber is a huge box girder. In its normal uses the walls and cross-ties are subject to tension only, and are in equilibrium, not tending to change their form, but accidental extraneous forces may tend to cause compressive strains, which the structure will sustain.

The roof of the air chamber, which also forms the floor of the lock chamber, is framed on heavy plate girders.

The hydrostatic pressure on the side walls of the lock chamber is sustained by brackets; those on opposite sides being tied by the floor plates.

The gates are crescent-shaped box girders, moving orbitally on a wheel, and when open lie out of the way in segmental side pockets.

The seating faces are concentric with the vertical axes about which the gates move orbitally.

The gate-opening engines have each a cylinder 14 inches bore, 8 feet stroke, the piston moved by compressed air, the piston rod carrying a cut steel rack, 4 inches pitch, 7 inches face, which meshes with and turns a pinion keyed to one end of a shaft, on the other end of which is a sprocket wheel geared by a Yale & Towne 9-16-inch chain to a sprocket wheel on a vertical shaft, secured in bearings on the gate post. This driving shaft has spur pinions at top and bottom, which mesh with pin-wheel segments on the gate. When the piston moves, the connected rack turns the shafts and pinions and operates the gate.

The gate is lightened by a flotation chamber, which floats 74 per cent. of its weight, leaving 26 per cent. on the wheel to give stability. The air which fills the flotation chamber is constantly renewed, so that the gate will not get logy.

The gates which are liable to be rammed contain elastic trusses, with a yield of 10 inches, which cushion the blow and deliver it to the gate posts, so that ramming has no effect on the gate itself until the elastic trusses are broken.

The gate openings are slightly wider than the locks, so that the jambs are not liable to ramming, being protected by the guard timbering on the lock walls, which is as elastic as possible, to that end being supported in the centers of the plates on rubber cushions, so that the effect of

impact is distributed over a number of brackets and lessened by the elasticity of the guard timbering, its rubber supports and the plates.

When the lock is elevated, as aforesaid, it is superbuoyant, having an excess lift exceeding the accidental increase of load which might occur through the sinking of a loaded boat, and this excess lift is restrained by anchors, which are steel plates secured to the bed rock, and encased in asphaltic concrete piers. On them are built the side guides and the fixed racks of the leveling apparatus. These are disposed in four transverse lines at the end and alternate intermediate intersections of the bays.

When the ascending lock comes to rest, its momentum is absorbed without shock, by hydraulic stops swiveled on the anchorages, with which the elevated lock engages, by brackets armed with timber contact pieces, which are readily movable, to allow the lock to be raised clear of the water for painting and repairs.

Automatic Leveling, or Synchronizing Apparatus.

During the years which have been devoted to developing the pneumatic lock, many different types of leveling apparatus were considered and more or less worked out, but were all prohibitive in cost, especially on a large scale. The characteristic features of that adopted are that it is always in action; has only rolling friction, normally sustains only its own weight, has the minimum wear and abundant end clearance, which prevents binding and temperature strains. It can be made of any power, and the larger it is made, the less will be its cost per pound. It does not require nice workmanship, or careful adjustment. It is what engineers call a "brute."

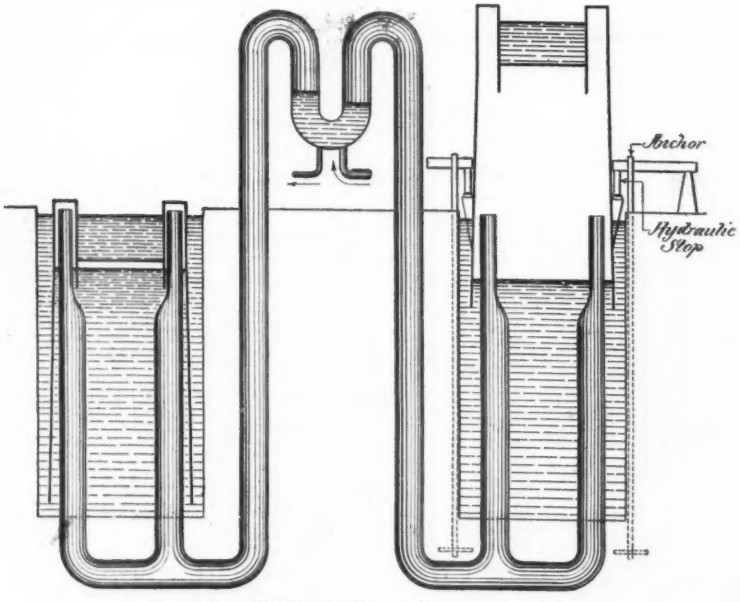


DIAGRAM SHOWING
AIR CONDUIT AND VALVE

Its elements are vertical racks securely anchored to terra firma, parallel racks built integral with the lock; hollow riveted steel, rolling shafts parallel with the locks and carrying pinions which mesh

with the opposite parallel racks on the lock and on terra firma, the shaft having no bearings, but hanging upon its engaged teeth. When the locks move, the shafts roll between the racks and traverse one-half the stroke of the lock.

The preferred form of rack is the ladder type, with pin teeth. Small lock pinions may be cast. For large locks they must be built up of rolled steel, the core a forged drum, the blanks rolled steel rings with involute cut teeth. Such

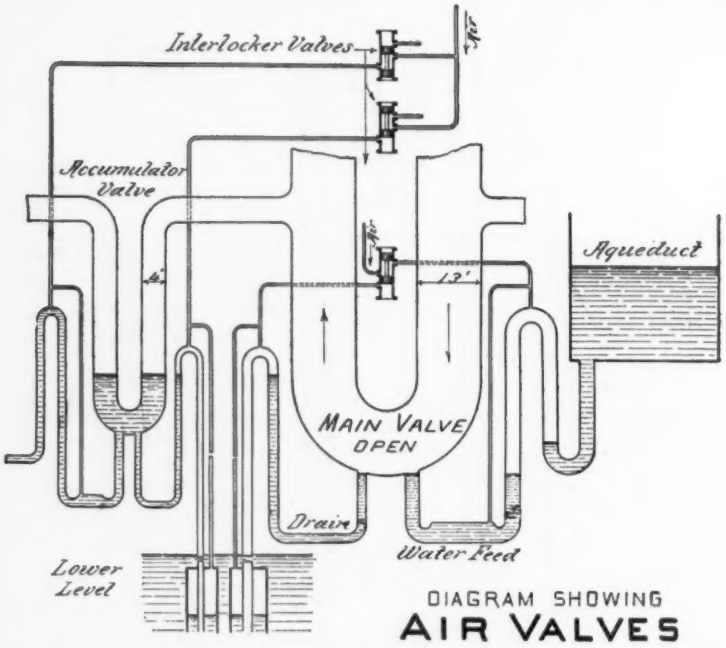


DIAGRAM SHOWING
AIR VALVES

a gearing would give undue wear, were it always subject to maximum working pressures, but for a lock it is, perhaps, the ideal form, as normally the teeth carry only the weight of the shafts; the maximum pressures, due to accidental unequal loading, being infrequent. In the Lockport locks the shafts are 4 feet in diameter, made of inch plate.

The pinions are double, cut on rolled blanks, 6 inches thick, the involute teeth 16 inches pitch, 60 square inch section at pitch line, 16 pinions and 960 square inches of metal in the teeth being in action.

The outside rack stringers are 15-inch channels, with inch webs, and the teeth 6-inch pins, riveted in.

Air Conduits.

The air main is 13 feet in diameter, and will transfer the entire air charge from lock to lock in one minute, with 330 tons surcharge in one lock.

The connection with each lock is by two open-ended standpipes, 10 feet diameter, which extend from the bottom of the lock pit considerably above the water surface, under hoods formed in the lock body. From their ends rock-cut tunnels run to the risers, which connect with the main valve.

The main valve is a "U" bend, provided with water inlet and drain pipes, so that the bend may be trapped with water and untrapped to shut off or permit the flow of the air.

The water-supply and drainage to and from the valve is controlled by pneumatic weirs, which are the reverse in principle

of the air valves. A water-feed pipe extends from the upper level of the canal to the lower part of the main valve, and is formed like an S, with upper and lower bends. A similarly formed drain connects to the bottom of the main valve, rises to an upper bend and descends into and is sealed in the water of the lower level.

Air-supply pipes lead from the upper bends of the said water-feed and drain pipes to a 6-inch double-acting air valve, which is part of the interlocking machine in the operator's house. When this

ure into the weir of the drain and to "waste" air from the weir of the feed. The air escapes from the feed weir and permits water to flow from the upper level into the main valve and seal it, and such water seal is prevented from escaping by the air-trap in the upper bend or weir of the drain.

Similar valves, 4 feet in diameter, open into the legs of the main valve and connect by a 4-foot main with a pneumatic accumulator, which may be thereby connected with or cut off from either lock.

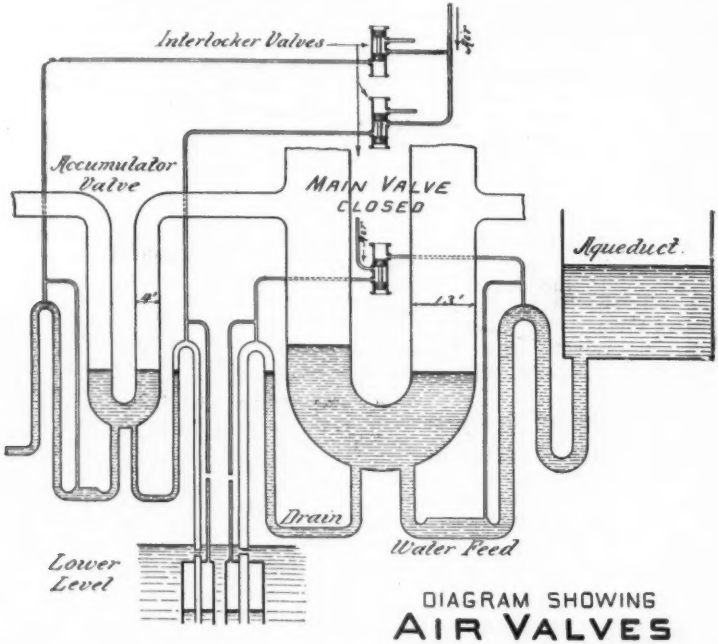


DIAGRAM SHOWING
AIR VALVES

6-inch air valve is moved to "feed" the air to the weir of the water-feed, and to "waste" the air of the drain weir, the air pressure enters the upper bend of the feed and seals it against the passage of water; at the same time the air pressure wastes from the upper bend of the drain and the water drains out of the main valve, opening it to the passage of the air.

When it is desired to close the main valve, the 6-inch air valve at the interlocker is moved to "feed" the air press-

Pneumatic Accumulator.

The pneumatic accumulator is a cylindrical bell, or open-bottomed air tank, having an upper weight chamber filled with water, and gives a constant working air pressure. When a lock is elevated it is immediately connected with the accumulator, which maintains a constant working pressure and automatically compensates for varying density and temperature in the adjacent atmosphere, which would otherwise vary the working pressure.

Interlocking Apparatus.

In order to prevent the operator from making mistakes, all the operations necessary to translate the locks are controlled by an interlocking apparatus, or sequence machine. This machine has five levers, on vertical interlocked stems, which are geared to horizontal shafts carrying cranks directly connected with the stems of air valves, so that when the operator swings a lever he directly operates an air valve, and at the same time locks the lever behind him and unlocks the lever in advance, in order of sequence.

All the transmissions are by compressed air, and are controlled by the aforesaid valves of the interlocker, and critical motions are further controlled by stops operated by compressed air piped to them from valves at the gate posts, so that if any gate be off its seat the apparatus is firmly locked and cannot be moved until each and every gate is properly seated.

The interlocker is in a three-story operator's house, all the valves and pipes being in the lower, the operating story containing only the levers and the table which carries them.

The tubular valves have balanced spools, cup-leather packings and bronze-lined shells.

Automatic Stopping Machines.

The automatic stop machines prevent the locks from rising too high, or running away, and control the amount of surcharge taken on the elevated lock, which is the working force of the system. To this end they control the hydraulic valves of the hydraulic stops.

Because air is elastic, the motions of the ascending and descending locks are not exactly synchronous, the ascending locking leading the descending lock. Therefore, stop machines are independent for each lock. They operate only when the lock is in the upper limit of its stroke, and are adjustable to compensate for varying heights of water in the upper level.

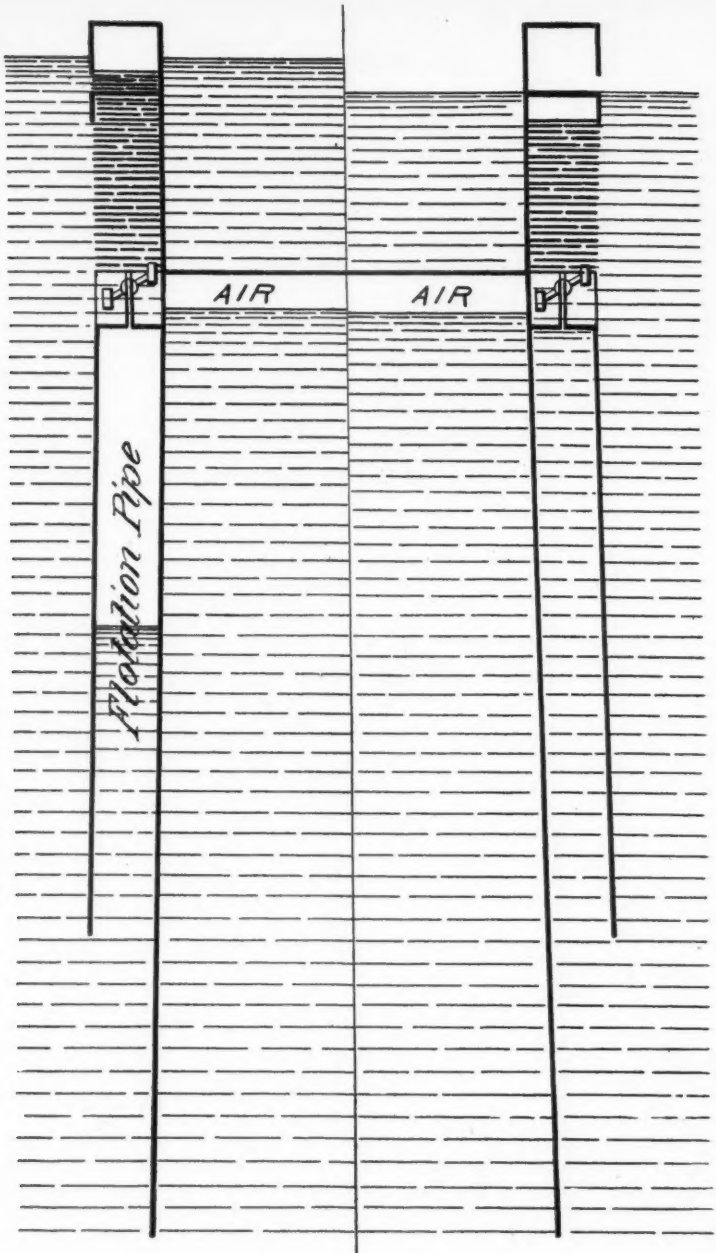
Each lock operates its machine by chain gearing turning its main shaft, which carries a drum having a differential thread, one end being of 1-inch pitch, the other 36-inch pitch, the latter cut in an enlarged part, the slow thread being idle, merely keeping the parts in mesh while it is not desired that the lock should function the machine.

The thread moves a sliding bar, which has on one face a differential tooth meshing with the thread of the drum, and on the other an operating face, consisting in a rack and plain guiding surfaces coincident with the pitch lines of the rack. Engaged with this bar is a pinion segment, having a toothed portion and plane faces tangent to the pitch circle.

During the greater part of the lock stroke the differential tooth meshes with the slow thread on the drum, the plain faces of the bar and segment engage, and the machine does not function. When the lock approaches the upper limit of its stroke, the differential tooth meshes with the quick thread, the rack meshes with the toothed portion of the segment, and the machine functions; the shaft carrying the segment being connected with a parallel crank shaft by double gearing, the gears on the crank shaft being loose and rotating it by ratchet gearing, so that it is always turned in the same direction, whichever way the segment may be rotated. One end of the crank shaft connects by a crank and link with the main hydraulic valve. The other connects with a positive differential crank motion directly actuated by compressed air from the interlocker, and such that dead centers are avoided and the slip of the valve is taken up twice during the complete cycle. The lock opens and closes the hydraulic valve by rotating the segment. The operator opens the said valve, takes up slip, and brings it to a fixed position by admitting compressed air to a piston of the differential apparatus, which is so geared that when the differential crank rotates 144°, the valve crank rotates 210°, and when the lock rotates the valve crank 150°, completing its revolution, the differential is rotated 216°, and completes its revolution.

Hydraulic Accumulator Intensifier.

This machine gives the operator perfect control of the elevated lock. It is so designed that by operating a valve it will give either a higher or lower working pressure. When the lower pressure is admitted to the hydraulic stops, the lock will retract the stops and raise the accumulator weight. When the higher pressure is admitted to the stops, they will force down the lock.



LOCK FOUNDERED | LOCK AFLOAT

Ready to ascend

The weight is a tubular concrete block, with an annular water tank for increasing the load. The frame is central in the well of the weight and sustains the hydraulic members, which are a lower 20-inch cylinder, a 20-inch ram carrying the weight and bored to form the cylinder for an upper 11½-inch ram working therein.

The two cylinders are connected by a valve-controlled pipe. When the valve is closed, all of the water expelled from the 20-inch ram is piped to the hydraulic stops, the pressure being 1,086 pounds. When the valve is open, one-third of the water expelled from the 20-inch cylinder goes into the 11½-inch cylinder and intensifies the pressure, raising it to 1,623 pounds.

This is an example of work equivalent. The work done is the descent of the accumulator weight. If all of this work goes into the stops, their work collectively is equal to the volume swept through by the accumulator ram at low pressure. If but two-thirds of the water passes to the stops, and one-third goes to the intensifier, it is evident that the same work must be done by the stops in a stroke two-thirds of the stroke of the weight, and, therefore, the pressure must be increased one-half.

The machine is also a mechanical proof of the mathematical summation of series. In the case given the intensifier ram is practically one-third the area of the accumulator ram. Therefore, when the valve is opened, the pressure in the accumulator cylinder reacts through the intensifier cylinder and raises the pressure in the accumulator one-third. This one-third reacting in the same manner, raises it one-ninth. The one-ninth increase raises it one-twenty-seventh, which raises it one-eighty-first, which raises it one-two-hundred-and-forty-third, and so on to summation:

$$\frac{1}{3}+\frac{1}{9}+\frac{1}{27}+\frac{1}{81}+\frac{1}{243}+$$

et cetera, the sum of which is one-half.

Operator's Control of the Elevated Lock.

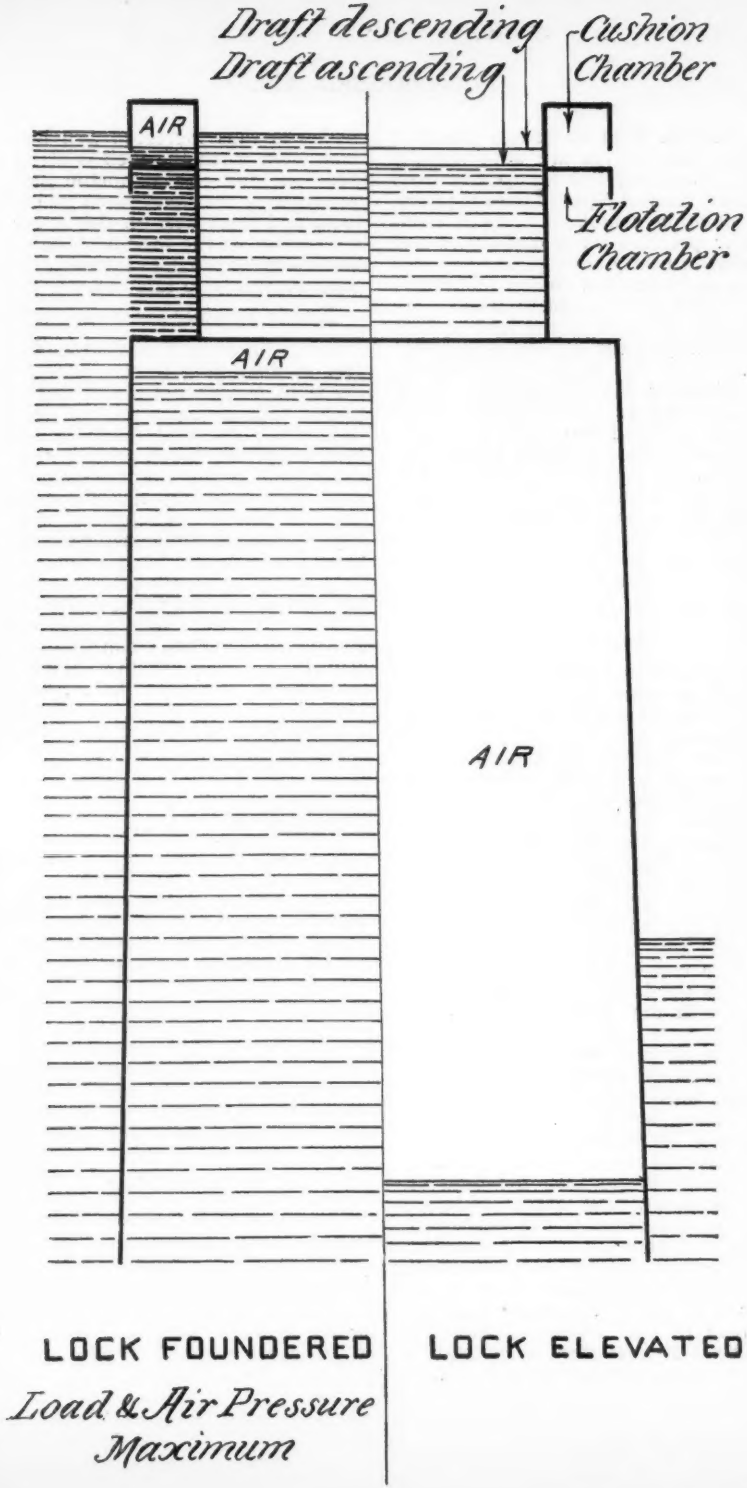
Swelling the Boats In and Out.—Experience proves that the entry and exit of boats to and from locks is much easier if water flows with the boats. Therefore, the ascending lock holds a depth of water considerably exceeding the least working draft, and when it approaches the upper limit of its stroke is automatically stopped, with the water in the lock chamber on a level with that in the aqueduct, so that as soon as the space between the adjacent lock and aqueduct gates is filled with water the said gates can be opened, without adjusting water levels, thus making a great saving in time. A further saving is made by swelling the boat out into the aqueduct. To do this, the operator moves a lever at the interlocker, which opens the main hydraulic valve, the intensifier valve being at such time closed, whereupon the lock retracts the hydraulic stops, rises and discharges its surplus water into the aqueduct, swelling the boat out, the upward motion of the lock being properly automatically arrested by the automatic stop machine.

As the boat which is to be locked down enters the lock, the operator swings a lever in the interlocker, which simultaneously opens the hydraulic valve and the intensifier valve, bringing the intensifier into action, the hydraulic stops forcing down the lock, which takes on a surcharge of water, which swells in the boat, the downward motion being properly automatically stopped. If now the gates be closed, the elevated lock is ready for its traverse.

Automatic Control of the Depressed Lock.

In order to avoid nicety of adjustment and loss of time in connecting the depressed lock with the lower level, said lock founders until its downward motion is arrested and cushioned by the floating power of the cushion chambers at the sides of the lock chambers. There are longitudinal flotation chambers beneath the cushion chambers, from which the air is discharged as the lock is immersed, so that the lock may founder; after which both gates are opened, so that water can come in behind the boat, as it is drawn out, giving it free motion.

The lock descended surcharged with water and now contains a maximum draft. In order to ascend, it must be lightened. For this purpose there are vertical long flotation pipes, of small cross-section, which, when the lock is elevated, communicate with the atmosphere and take in a charge of air at atmospheric pressure. As the lock descends this air is held and compressed, its pressure being a maximum and its flotation a minimum


Draft descending
Draft ascending
Cushion Chamber
AIR
Flotation Chamber
AIR
AIR
LOCK FOUNDERED
LOCK ELEVATED
Load & Air Pressure Maximum

when the lock is in its lowest position; at which time valves are automatically opened, permitting this air to rise from the narrow vertical pipes to the long horizontal flotation chambers. As it rises, the water pressure on it diminishes and it expands to nearly atmospheric pressure and regains its original volume and maximum floating power, automatically increasing the flotation of the lock so that it floats with just the desired depth over the sill.

The minimum draft is 12 feet. Draft ready to ascend, 12 feet 6 inches. After the lock is elevated and connected with the aqueduct, it rises 6 inches, expels this surplus into the aqueduct, swells out the boat, and has its minimum draft over the sill. To take in the surcharge of water and swell in the descending boat, the lock is forced down 18 inches and descends with 13 feet 6 inches over the sill.

Automatic Increase and Equating of Air Pressure.

While the lock is moving, it is obvious that the air pressure cannot vary greatly from the pressure which would be in exact equilibrium with the load. If the walls of the chamber were parallel, the working margin of excess pressure must be greater, because the pressure of equilibrium would necessarily increase as the lock rose and the immersed portion of its walls became less; therefore, the locks are equated, so that the working pressure or pressure of equilibrium is constant, the sides being splayed, so that the projected area against which the pressure acts increases in a constant ratio from the upper towards the lower portion of the air chamber, with the decreased immersion of the walls.

When the elevated lock is arrested by the stops, it is necessary for its safe use that the air pressure and the flotation be increased some 30 per cent. This is done automatically by the descending lock.

The horizontal area of the air chamber is considerably larger than the floor of the lock chamber, such excess equaling the sums of the areas of the horizontal segmental projections of the air chamber beyond the line of the lock chamber. When the lock is elevated, there is no water on these plates, but as the lock descends they become immersed, and the weight of water upon them is necessarily carried by the air charge, the pressure of which is thus increased and becomes a maximum when the lock is at its lowest position; and this automatic increase of pressure is transmitted to the elevated lock, and there acts on the larger pressure surface at the lock bottom, and thus automatically provides the excess of buoyancy necessary to safe use.

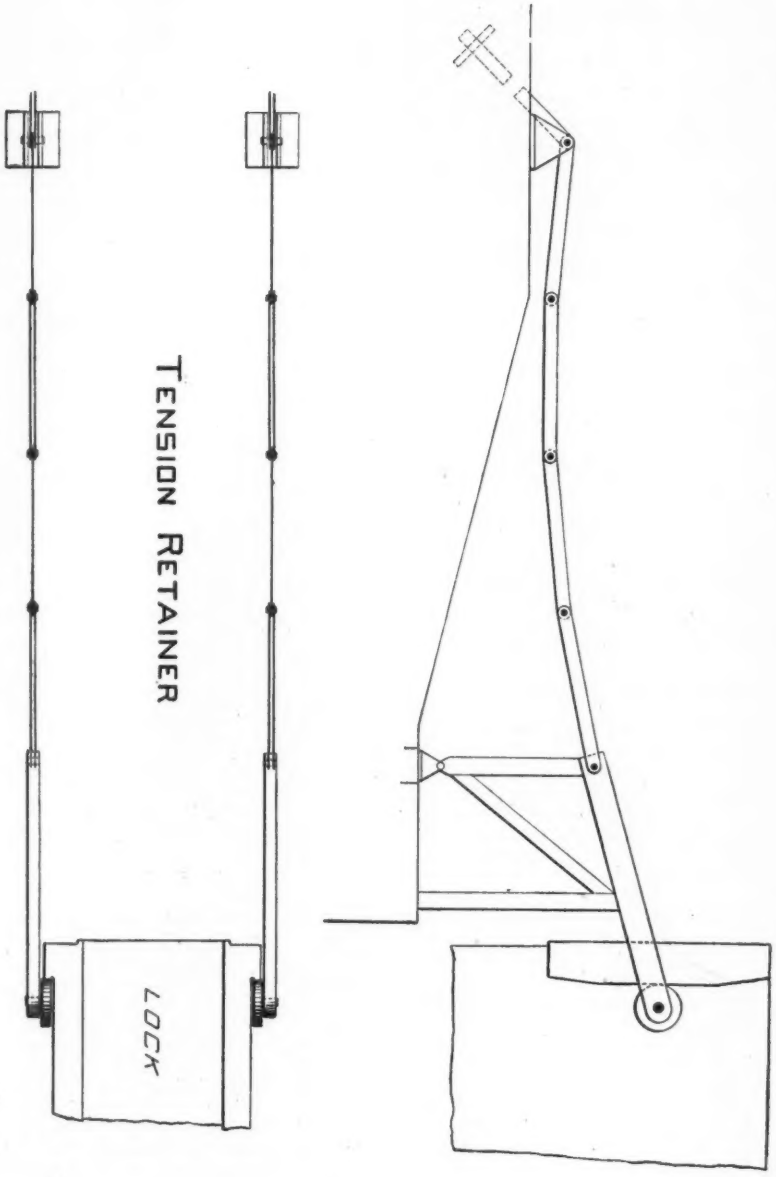
Elastic Retainer for Elevated Lock.

While the lock is moving it is not subject to disturbing forces, except that of the wind, but when it is elevated and connected with the aqueduct, the unbalanced hydrostatic pressure tends to force the lock away and break the joint; and because boats might ram the outboard lock gate, it is necessary that the connection have flexibility to cushion the blow. These ends are compassed by tension retainers, which are I-bar cables, 220 feet long, hanging in catenaries, anchored at one end to the bed rock, at the other retaining the hydrostatic pressure in the end of the aqueduct, or in the lock when connected, the connection being retaining wheels, 12 inches thick, 5 feet diameter, with 15-inch journals, adjustable in bearings formed in the end frames of the retainers, the wheels engaging shoulders on the lock, which are runways planed on heavy steel castings, riveted into and forming flanges of the portal columns of the lock body. A blow will pull the cables into flatter curves, the endwise motion cushioning the shock.

The joint is made water-tight by a dilatable rubber tube, secured to the aqueduct face, and seating at any point on a flat timber apron provided on the adjacent end of the lock. The tube is cured flat, and remains so when deflated. To make a joint, it is inflated by compressed air admitted from a valve of the interlocker. The space between the gates is flooded and emptied through pipes controlled by pneumatic weirs, which, in turn, are controlled by air pipes leading to valves at the interlocker.

Power Plant.

There is a 36-inch double-balance turbine, belted to a duplex air compressor, to a four-cylinder, high-pressure hydraulic pump, and to a dynamo for lighting. Also a high-pressure air tank, and a tank for the hydraulic supply, it being intended to operate the hydraulic apparatus with 500° test petroleum.


TENSION RETAINER
LOCK

Aqueduct.

The necessity of operating the old locks while the new ones were being built compelled the use of an aqueduct, 393 feet long, to connect them with the upper level. This aqueduct is so designed that the strains due to the static load oppose and cushion the strains induced by collision of vessels using the aqueduct. This principle develops the full elastic quality of the steel, makes the sides four times as flexible, and the flange strains less than one-eighth as great as those obtaining in aqueducts heretofore designed; the builders of which apparently ignored the destructive effect of shocks or assumed that the boats could be drilled so as not to collide.

Instructures of the old type the flange strains in the frames are due to the sum of the static and shock moments, and the elastic cushioning movement of the side walls is that due to the variation in the one kind of strain, for example, tension, to which the flange is subjected. In the design exhibited, the flange strains are equal to one-half the difference between the static and shock moments, and reverse from tension to compression, or vice versa, so that the elastic movement is four times as great, the greatest which the metal is susceptible of without injury.

General Principle of Construction.

The floor is not framed, but suspended at the edges, and the weight thereon exerts an inward pull on the frames in opposition to the hydrostatic pressure on the sides. By suitably proportioning the parts, these forces can be given any desired ratio. The inward moment of the floor exceeds the sum of the outward moments, and induces compression in the upper and inner flanges, and tension in the outer and lower flanges below the floor line. When a boat strikes the side, the stresses are reversed.

This particular design could not be applied to the end bays, where the gates are located. Therefore, the principles were applied in a different manner, the flat floor being carried by transverse girders spliced to the side walls, which are framed as girders and connected to the inner vertical flanges of the frames which are suspended from their outer flanges on links and pins, so that under the static load the outer and under flange is in tension, and the upper and inner flange in compression. When the boat strikes one side, its shock is cushioned by the elasticity of the entire frame, and before it can have a destructive effect, it must reverse the strains in both flanges, swing the end of the aqueduct to one side and somewhat raise it. This design can be made much more effective with an equal weight than that adopted for the intermediate bays, because the shock is cushioned by the elasticity of the entire frame, whereas the other design cushions by the elasticity of half the frame.

As the designs for the aqueducts have been very materially improved since this address was delivered, the reader is referred, for full information concerning them, to U. S. patents 621,470, of March 21, and 626,321, of June 6, 1900, issued to the author.

While every precaution has been taken in the design to prepare the structure safely to resist a maximum shock, the interior of the aqueduct is protected with elastic timber guards, which, if they be properly maintained, will absorb the greater part of the shocks without much strain to the structure. But, obviously, a structure which may be put into the keeping of incompetent men, appointed for political purposes without regard to their fitness, must be so designed that no fool can cripple it, so that it might be wrecked by improper use. Therefore, the aqueduct is designed with such great care, and is much more costly than would be desirable were it owned and operated by a private corporation, which would exercise reasonable care in its use and maintenance. The same is also true of the locks.

How the Locks Work.

The depressed lock floats and requires no care. The elevated lock is connected with the pneumatic accumulator, and the air pressure in it is 8⅛ pounds per square inch, which expels from it a weight of water 30 per cent. greater than the weight of the loaded lock, giving it the excess buoyancy necessary to its safe use; said excess buoyancy being restrained by the anchors. When the elevated lock first ascended, it engaged with the retainer the joint was packed by inflating the rubber pipe, the space between the lock and aqueduct gates was flooded with water, the gates were opened, the boat was

swelled out into the aqueduct, to accomplish which the hydraulic valve controlling the stops was opened and the lock retracted them and raised 6 inches. As the descending boat entered the lock, the intensifier was brought into action, the lock was forced down 18 inches and took on its surcharge of water, swelling in the boat, such lock motions being automatically stopped by the stop machine. The gates of the depressed lock, and the adjacent gates of the elevated lock and aqueduct can now be closed, and the space between them drained. The accumulator valves are now closed, the main valve is opened, and the air expands from the elevated lock into the depressed lock, raising it and at the same time lightening it as it rises, by reducing the extraneous load of water on the projecting horizontal segmental plates at the tops of the air chambers. This function continues until the air in the elevated lock has expanded to less than equilibrium with the weight thereof, so that the elevated lock can descend, at which time the depressed lock has been raised so high and the extraneous load thereof so decreased, that the pressure of equilibrium therein is less than in the elevated lock, from which time the depressed lock ascends until it is fully elevated and is brought to rest by the hydraulic stops, and the elevated lock descends until the segmental plates at the tops of the air chambers are immersed and begin to take on the extraneous load, which increases as the lock descends, and the plates are

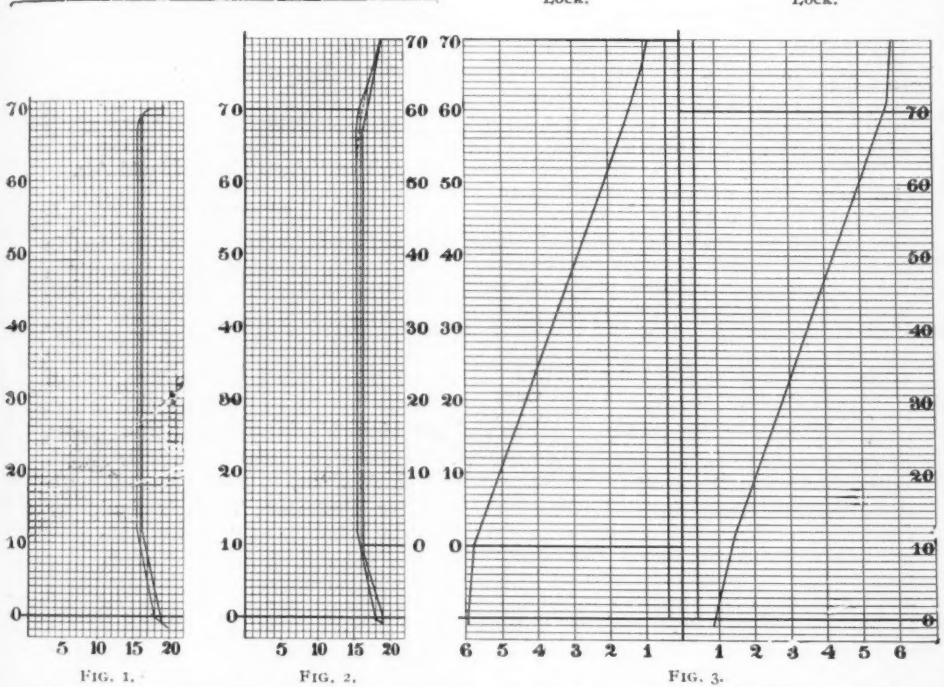


FIG. 1. FIG. 2. FIG. 3.

Vertical ordinates read stroke in feet. Abscissas read feet of water pressure, or "head" on air charge, in *Figs. 1* and *2*; and in *Fig. 3* read 100,000 of cubic feet of compressed air as distributed between the two locks during their cycle, the central ordinate indicating the position of the valve and the adjacent rectangles the conduits. In *Fig. 1* the stroke of the descending lock reads downwardly, with the motion; in *Figs. 2* and *3* all strokes read upwardly so as to show relatively coincident conditions in the two locks.

immersed to greater and greater depth, such extraneous load and the air pressure becoming maximum when the lock has descended to its lowest position. This maximum pressure acts in the elevated lock at the large bottom portion thereof, and induces therein the excess buoyancy necessary for its safe use. The main valve is then closed, and the accumulator valve opened, connecting the accumulator with the elevated lock, which can then be connected with the aqueduct. Both gates of the depressed lock are then opened, which is thereafter automatically floated to a higher position relatively to the surface of the water of the lower level, in which it floats, so as to contain the draft of water with which it should ascend.

The pneumatic lock will wholly change the conditions of canal construction. Heretofore, the range of usefulness and the location of canals have been limited by the water supply available for feeding the locks from the summit level, and it has been necessary to maintain the water level within narrow limits; and the large amount of water and the heavy currents necessary in locking have necessitated a constantly running supply and spill ways for the escape of such supply, when the locks were not operated. The small lift of the Leonardo locks necessitated the selection of gentle slopes for the lock sites, which, in many cases, involves soft foundations. In canals planned with pneumatic locks, the most economical plan will be to make the levels as long and the locks as high and few in number as possible. Guard locks and the waste of water can be entirely dispensed with, and the summit level can be utilized for storage, its banks being high enough to contain the highest and its bottom low enough to give the desired draft at the lowest water, the variation being taken up at the lock. In most canals the heavy tonnage is one way, and down hill. In such cases the descending tonnage will not only operate the lock, but also lift water to the summit level. It will be seen that the first cost of canals and their demands on the water-supply are reduced to a minimum. Application of steel to the locks reduces their cost of installation, operation and maintenance as greatly as it has reduced such costs in other engineering structures. The state authorities estimate that the saving in wages at Lockport will exceed interest on the entire cost, and at Cohoes such saving will be double the interest on the cost of installation, so that building the Cohoes locks will save an actual profit. In ship canal locks the saving will be in ratio increasing with their size.

Liquid Air

Speeds an "Auto" with Liquid Air.

Liquid air is having a practical test in propelling an automobile. Recently a public test was given to some newspaper representatives at the plant of the Tripler Liquid Air Co., New York. A gallon of the queer liquid was poured into a tank, the aperture through which it had been poured was closed. The gallon would carry the automobile seven miles, said G. A. Bobrick, chief chemical engineer for Professor Tripler's liquid air company, who was at the lever. He gave Senator John P. Jones, of Nevada, and several others invited to the exhibition a ride of half a mile or so on the Boulevard.

Before exhibiting the automobile, Mr. Bobrick showed to representatives of New York's big refrigerating companies a miniature plant supposed to represent the liquid air equipment of a large hotel. His engine was on an ordinary table, much of the accompanying machinery was of glass, so that the working could be observed and explained to the lay mind. A gallon of air was used. The machinery was made to operate a refrigerating plant, an electric light and heating plant, to supply power for everything that power is

needed for in a hotel, and, finally, to consume the garbage and refuse with lightning-like rapidity.

When Mr. Bobrick brought out his automobile Mr. Tripler explained that it was merely an improvised affair to show tentatively what could be done without much preparation. The "works" had been removed from an ordinary gasoline automobile, and the liquid air apparatus put in its place. The latter consisted of two ten-gallon copper tubes, placed together in the back part of the wagon bed, and another copper tank, forward, underneath where the feet of the driver rest. These with the various pipes weighed only 125 pounds, while to this must be added the weight of a small engine, that already in the automobile, 33 pounds. The gauges and other indicators used before were retained, since the air pressure is measured just as though it were steam.

After the liquid air was poured into the receptacle there was a wait of about ten minutes while the pressure was coming up. Mr. Bobrick explained that if pressure was wanted in haste it could be secured by taking the vapor generated direct from the tank into which the air had been poured, but when there was no hurry the pressure came from the reservoir or secondary tank, being that in the rear next to the main tank. The liquid air seethed, bubbled and smoked as it was poured into the tank, or, properly, the boiler, but when you put your fingers in it they were frozen stiff in a jiffy. Soon the boiler took a thick coating of snow, which covered also most of the pipes, suggesting that in travelling by air automobile one always had a refrigerator with him to keep his provisions fresh.

The automobile is controlled and otherwise operated as though steam or oil gases were being used, and it was noticed that the vehicle moved noiselessly as to its machinery, there being no thumping nor any of the other noises heard when some of the new-fangled wagons are in motion.

That liquid air moves the automobile is not to be doubted; that it will be of practical use in that field Professor Tripler said he was certain.

Air Jets

We have received two interesting and valuable books from Norman W. Henley & Co., publishers, 132 Nassau street, New York.

The first relates to Horseless Vehicles, Automobiles and Motor Cycles operated by steam, hydro-carbon, electric and pneumatic motors. While we are only concerned in the last-mentioned, the whole book is one that covers the field in the usual thorough manner of Mr. Gardner D. Hiscox, M. E., who is well known to our readers. It has 459 pages, 316 illustrations, is handsomely printed and bound and sells for $3.00. It contains a complete list of the manufacturers of these vehicles with addresses and patents.

Book No. 2 is a practical treatise describing in every detail the actual building of a gas engine, by Henry V. A. Parsell and Arthur J. Weed. It is very fully illustrated and nearly 300 pages. Price $2.50.

On June 30 last Mr. Edward N. Hurley, president of the Standard Pneumatic Tool Company, sailed for Europe for the purpose of establishing works in Germany and France, for European trade. This company already has large works in Chippenham, near London, but the condition of trade on the Continent warrants the establishing of works in the countries mentioned.

Mr. Hurley will be in attendance at the Paris Exposition, where there are two large exhibits of pneumatic tools and

appliances of the "Standard" make. He will be absent for about two months.

The General Electric Co. of Schenectady, N. Y., have adopted pneumatic hammers and other compressed air appliances in their works. An order was recently given to the Chicago Pneumatic Tool Company for several hammers.

The new round house of the Chicago & Northwestern R. R. at Clinton, Iowa, is probably the largest in the world. A feature of the conveniences is the pneumatic ash hoist, which was designed by the assistant superintendent of the road, Mr. G. R. Henderson. It is automatic so far as dumping of cinders and closing the pan lid is concerned, and it works very satisfactorily.

Pipe bending machines operated by compressed air are being placed in many railroad shops throughout the country.

In the Bloomington shops of the Chicago & Alton Railway there is a pneumatic bending machine that probably excels anything yet made in this line. The former blocks and wheels can be instantly changed or adjusted and the bending pressure can be applied to any extent needed as is desired.

The King sandblast which has been adopted in several foundries is of very simple construction, consisting merely of a flexible hose and a receptacle for feeding the sand.

"The Quarry," of London. gives the following account of rock drilling contests held in Great Britain that will be read with interest in America:

At the Oakeley Quarries, Festiniog, some interesting experiments were made with air and electric drills. Great interest was taken in the experiments, and they were witnessed by a large number of gentlemen who had been specially invited. The arrangements had been excellently made, and were carried out without a hitch by Mr. Roberts, the quarry manager. Rock drills had been provided, to be driven by both powers, the borings being made in rock of the same quality by both, for the purpose of ascertaining the comparative utility of air and electricity as motive power for this work. The results are very interesting. In three hours and twenty-three minutes, with a 2½-inch drill, the electric apparatus bored a hole 5 ft. 10 in. in chest, while the air drill, under similar conditions, bored exactly 9 ft. in two hours and ten minutes. The electric apparatus, with a 2-inch drill, bored through 8 ft. 7 in. of bastard slate in three hours twenty-three minutes, while the air apparatus, also using a 2-inch drill, bored through 5 ft. 10 in. of chest in one hour and 35 minutes. It will therefore be seen that the boring power of the air drill is considerably greater than that of the electric apparatus.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz., all communications should be written on one side of the paper only; they should be short and to the point.

Compressed Air, New York.

In our desire to promote the cause of your publication we should be glad to have you indicate the best location you can give us for a quarter page contract for one year at $50.00. Yours truly,

The Westinghouse Companies Publishing Department.

By W. M. Probasco.

Pittsburg, Pa., June 18, 1900.

Clinton, Mass., May 5, 1900.

Editor of Compressed Air.

Can you, or any of your readers, give me any information in regard to the air-injector as a means whereby high pressure air induces and compresses free air, at a low temperature? I have heard that such an instrument has been used, but have been unable to get hold of any particulars concerning it. Its use has been

suggested for the ventilation of tunnels, I think. Anything in regard to it, or any suggestions as to where I can get any such information will be thankfully received.

F. W. Bateman.

PATENTS GRANTED JUNE, 1900.

Specially prepared for COMPRESSED AIR.

651,741. — EXPLOSIVE LIQUID-AIR ENGINE. James C. Anderson, Highland Park, Ill. Filed Dec. 9, 1899.

An explosive-engine, a cylinder provided with a central exhaust-port, a reciprocating oscillating piston arranged within the cylinder and provided with diametric ports communicating with longitudinal passages extending to each end of said piston, a radial wing secured to the piston, a box-valve inclosing the radial wing, and provided with a port on each side, a valve seat or box inclosing the valve-box and provided on each side with an explosive-chamber and ports leading from each chamber to the valve-box, means for introducing air and hydrocarbon into the explosion-chambers and alternately exploding the same, and means for transmitting the reciprocating and oscillating movements of the piston to the rotary driving-shaft, substantially as hereinbefore set forth.

651,745.—METHOD OF MAKING COVERS FOR PNEUMATIC TIRES. Thomas Caldwell, Bolton, and William Caldwell, Leigh, England, assignors to the Radax Pneumatic Tyre Company, Limited, Warrington, England. Original application filed July 18, 1898. Serial No. 686,298.

The method of making a cover for a pneumatic tire, which consists in rendering a woven fabric, woven to the curve of the wheel, so far inextensible by stretching in a circular direction that the same when rubbered and made up will form a cover which holds itself securely on the rim under inflation.

652,178.—APPARATUS FOR DRYING AIR. James Gayley, Pittsburg, Pa. Filed Nov. 1, 1897.

Apparatus for drying air comprising a cooling-chamber, means for cooling the same, means for drawing air from said chamber, and an inlet to said chamber less than sufficient to supply the draft of air from the chamber, whereby a rarefied condition of the air in the chamber is maintained; substantially as described.

652,179.—AIR-DRYING PROCESS. James Gayley, Pittsburg, Pa. Original application filed Nov. 1, 1897.

652,270. — PNEUMATIC-TRANSFER-TUBE SYSTEM. Walter A. Houghtaling, New York, N. Y.

652,463.—AIR CLEANSING AND COOLING DEVICE. Joseph McCreery, Toledo, Ohio.

652,537.—TERMINAL FOR PNEUMATIC STORE-SERVICE SYSTEM. Hugo W. Forslund, Chicago, Ill., assignor to the National Pneumatic Service Company, same place.

652,559.—AIR-PUMP. Cicero M. Hobby, San Diego, Cal. Filed Aug. 1, 1899.

A receptacle closed to the atmosphere and having a liquid-inlet, a valved air-inlet, a siphon connected with the receptacle and having its arch rising above the top of the receptacle, a pressure-cylinder at the bottom of the receptacle, an operating-piston in said pressure-cylinder, a valve-chamber interposed in the outlet-leg of the siphon, and a valve arranged to control the connection of said chamber with the siphon and connected with said operating-piston.

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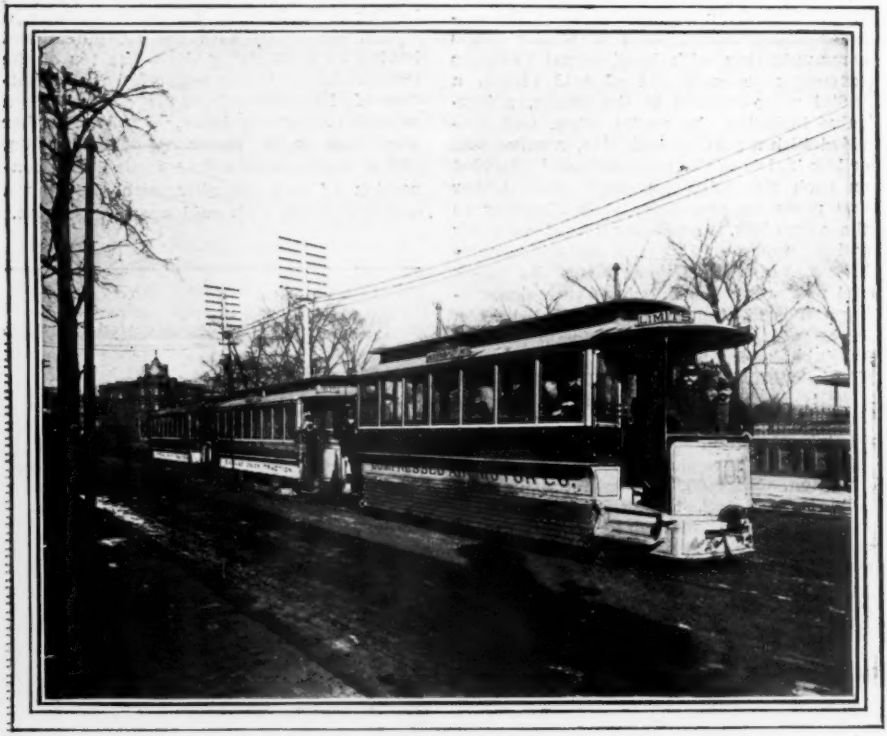

The above cut is of a 28 foot Compressed Air Motor Car hauling two trail cars in Chicago.

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Independent, under quick control, noiseless, of high efficiency, free from danger and all objectionable features. The most economical system in cost of installation, operation and maintenance ever offered to street and other railways. Thoroughly tested, both Winter and Summer, and endorsed by prominent engineers.

Cars, in size and appearance, are the same as electric or cable cars, the floor being no higher from rail. No paying space occupied by the air storage or mechanism, all being placed under the car floor.

RUN AT ANY SPEED DESIRED.
OVERCOME GRADES AND SHARP CURVES EASILY.
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Can be recharged with air in less than two minutes, and constructed to run any desired distance. Motors and entire load spring supported. Cars can be introduced one at a time on the track of any railway, steam, electric, cable or horse. Cars of this type performed a daily service of 81½ miles each upon 125th Street, New York City, for one complete year, during which time they ran 32,159 miles, and carried 188,854 cash fares, and are now, and have been since May 30, 1899, in operation on North Clark Street, Chicago.

The Metropolitan Street Railway Company, on 28th and 29th Streets in New York City, during the last three months of 1898 operated the line by horse power, and during the corresponding period of 1899 by air, with the following comparative results:

	1898 (horse)	1899 (air)
Number of cars employed, ...	16	15
Car mileage per day, ...	1310	1530
Number of passengers carried, . . .	1,183,170	1,681,580

In Chicago, where air cars were introduced for night service in place of horse cars, it has resulted in more than doubling the number of passengers carried during those hours.

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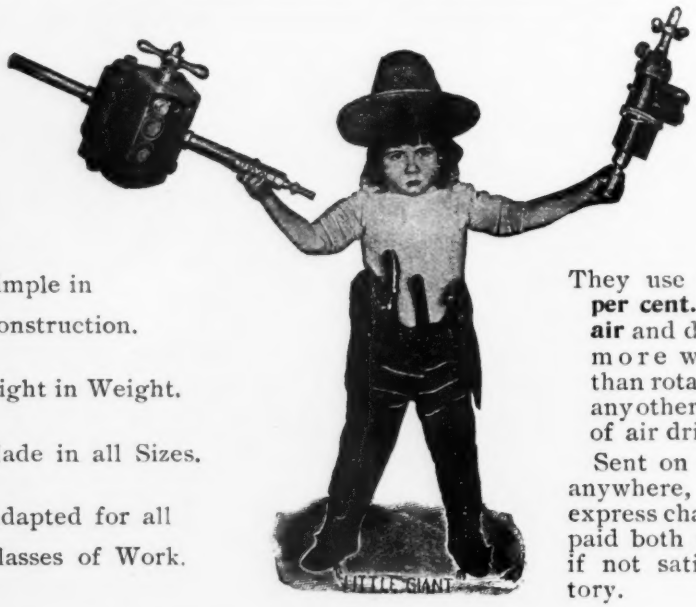

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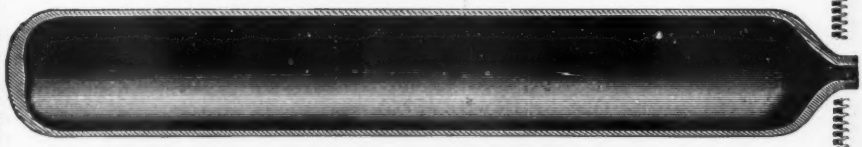

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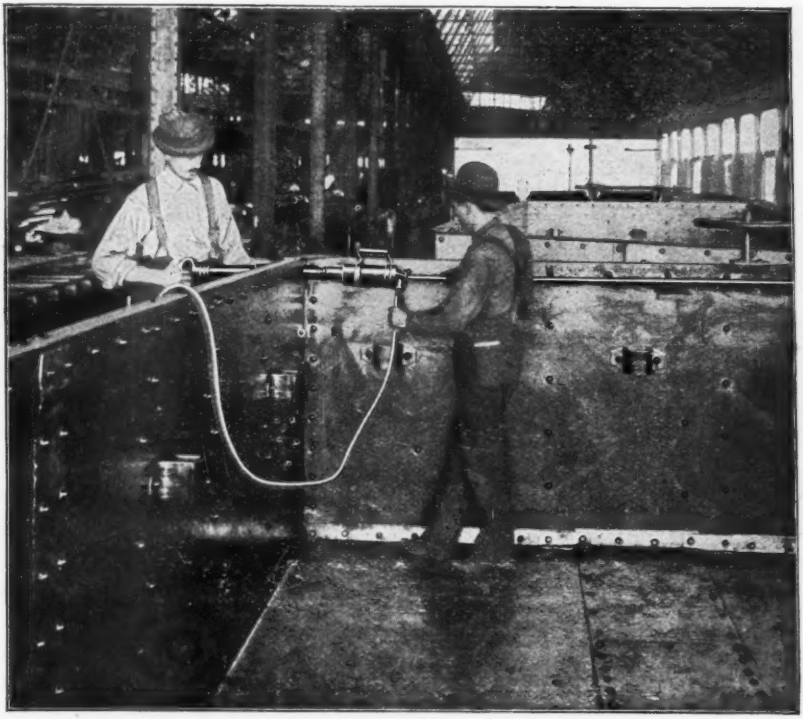

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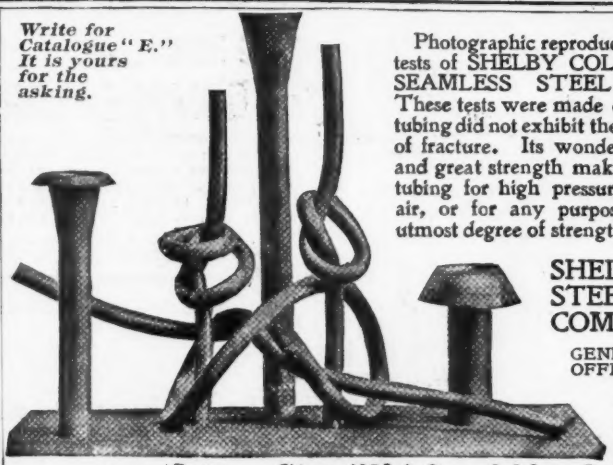

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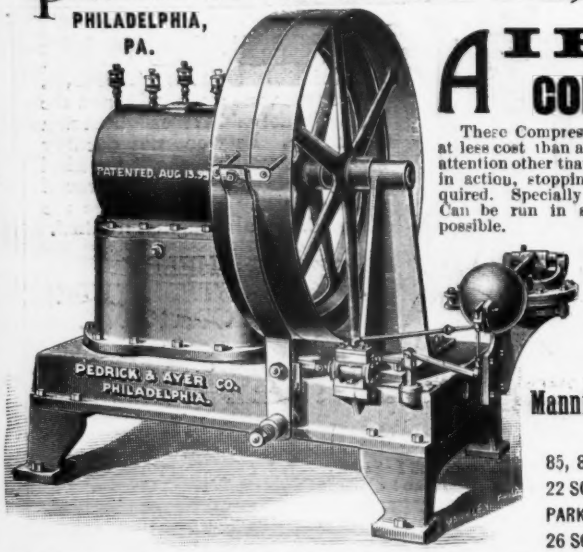

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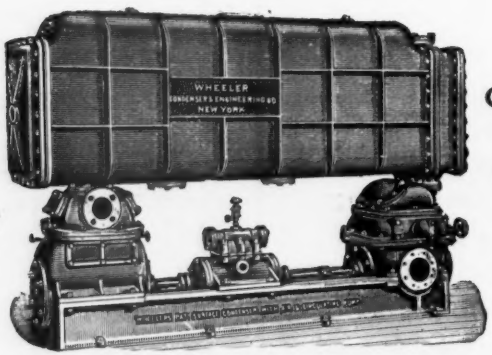

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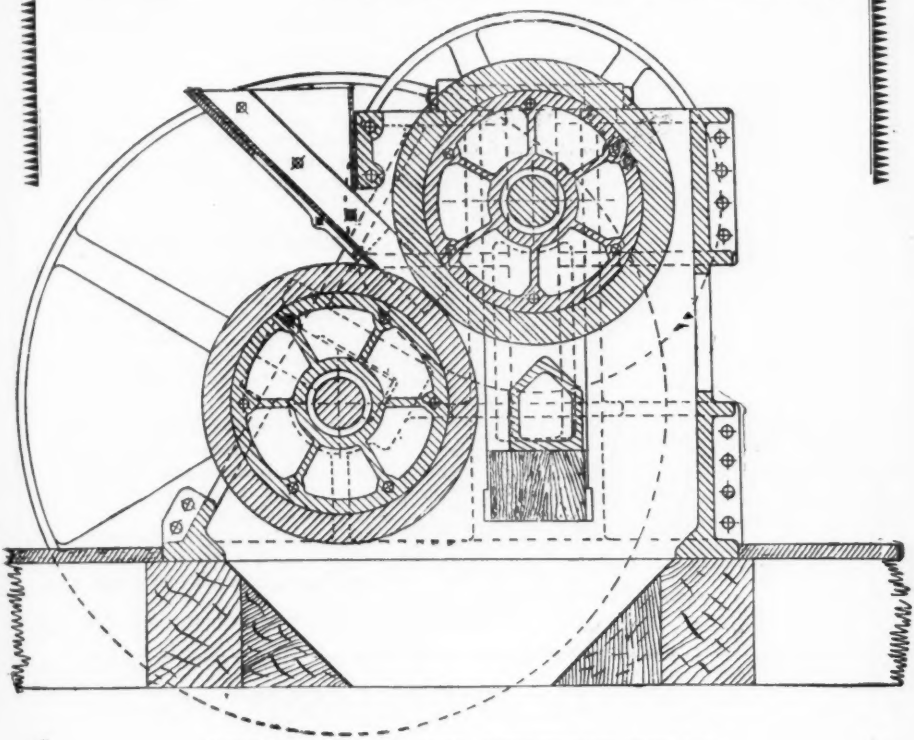

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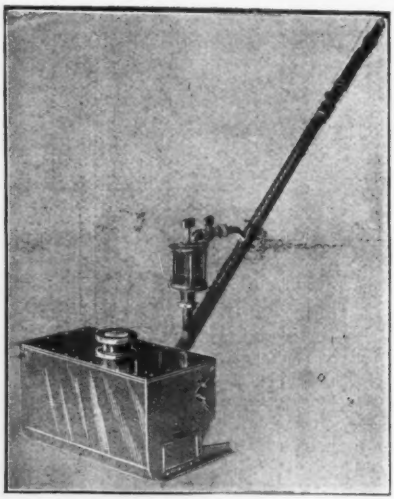

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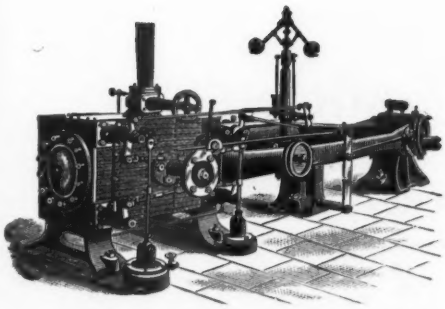

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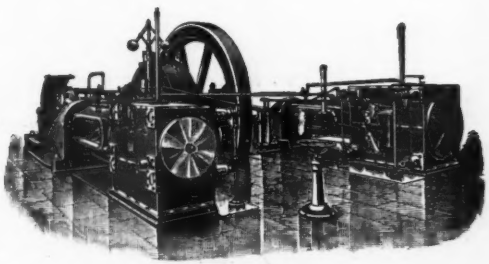

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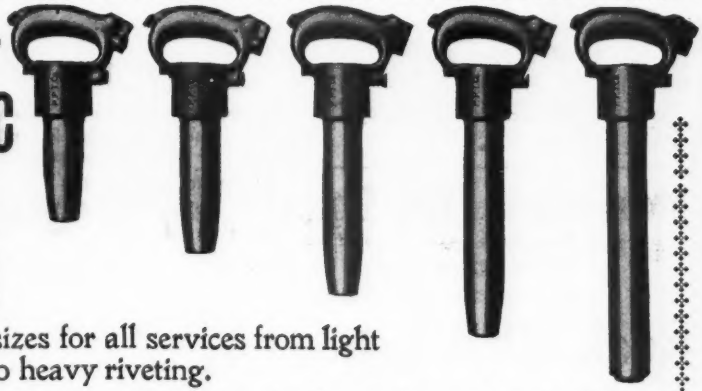

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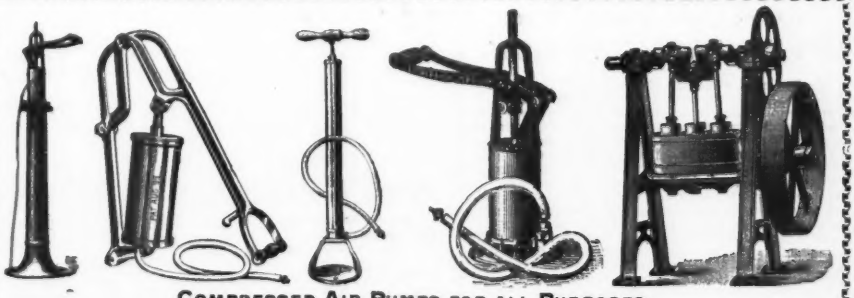

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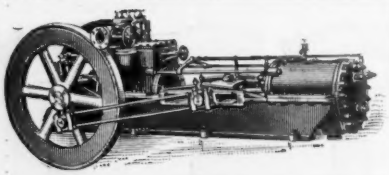

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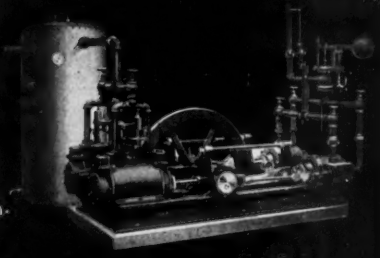

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